A.D. 1875, *5th August.* N° 2771.

Telegraphic Signals.

LETTERS PATENT to Sir Charles Wheatstone, Knight, of Park Crescent, Regent's Park, in the County of Middlesex, for the Invention of "**Improvements in the Mode of and Apparatus for Applying Electricity to give Telegraphic Signals and Work Telegraphic Relays.**"

Sealed the 28th September 1875, and dated the 5th August 1875.

PROVISIONAL SPECIFICATION left by the said Sir Charles Wheatstone at the Office of the Commissioners of Patents, with his Petition, on the 5th August 1875.

I, Sir Charles Wheatstone, Knight, of Park Crescent, Regent's Park, in the County of Middlesex, do hereby declare the nature of the said Invention for "**Improvements in the Mode of and Apparatus for Applying Electricity to give Telegraphic Signals and Work Telegraphic Relays**," to be as follows :—

My present Invention consists in a method or methods of employing for telegraphic purposes the motions produced when mercury is in contact with an electrolytic liquid within a tube of narrow calibre and electric currents are transmitted through them.

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Sir C. Wheatstone's Improvements in Telegraphic Signals.

The first part of my Invention relates to the employment of these motions as telegraphic signs, instead of the motions of magnetised needles within electric coils, or other means having the same object in view which are at present in use.

The second part of my Invention relates to the employment of these motions for the purpose of completing one or two local circuits by which a telegraphic instrument, either recording, permanent, or giving fugitive signs, or producing sounds, may be brought into action by means of electric currents transmitted through the main circuit.

The following is one manner in which the first part of my said Invention may be carried into effect:—A capillary tube, about $^1/_{60}{}^{th}$ of an inch internal diameter and about 6 inches in length, turned upwards at its ends, and terminating at its vertical ends in two reservoirs or cups, is fixed horizontally on a board having adjusting screws for the purpose of obtaining a proper level. This tube is filled with mercury, which rises into the cups and nearly fills them; but in the middle of the capillary tube a small quantity of dilute sulphuric acid or other conducting electrolytic liquid is introduced, occupying a space of about a quarter of an inch more or less, and kept in the middle by proper levelling. Immediately above the cups and plunging into the mercury are two platina wires, insulated except at their extremities, so that they may not come in contact with any electrolytic liquid at the surface; these wires are in metallic connection with binding screws, which are connected one with the telegraphic line wire, and the other with the earth wire.

The transmitting instrument placed at the other end of the telegraphic line is a current inverter with two keys connected with a voltaic battery, which according as the one or the other key is touched transmits a positive or a negative current to the line; the motion of the mercury thread in the receiving relay is always in the direction of the current that is from the copper to the zinc poles of the battery through the telegraphic line.

The construction of a current inverter with two keys being well known need not here be described.

When a key is kept depressed and the current consequently continues in the same direction, the column of mercury moves con-

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tinuously forward towards one of the reservoirs. This motion may by means of the reversing key at the transmitting station be checked, intermitted, or reversed, so that all the signals which a single needle magnetic telegraph is capable of showing may be exhibited at the receiving station. The motions, whether they follow in the same or in opposite directions, are distinctly marked and may be easily read. A single voltaic element of small dimensions will cause these motions through many hundred miles of standard telegraphic wire. If the power employed be too great the column of mercury will have a tendency to divide itself, but this, if not carried too far, will not injuriously affect the indications. The same construction of the transmitting key is equally applicable when the Morse alphabet is to be employed; the manipulation only will be different. The succession of long and short currents, which in this alphabetic system constitutes the sign of a letter, is effected by successively touching the same key; but a different key must be touched for each alternate letter. A great advantage is hereby obtained; the change of direction in the motions indicates clearly the transition from one letter to another, so that no error can arise from the running of the dots and dashes of one letter into those of the subsequent one.

Instead of the electrolytic thread dividing a mercury column as above described the capillary tube and reservoirs may be filled with the electrolytic liquid and the short space with mercury, or one-half of the tube may be filled with mercury and the other half with the electrolytic liquid; in all these cases the motions at the points of junction of the two liquids may be equally well observed, but I prefer the method above described.

To render the indications of the mercury thread more visible I place the tube in a camera arrangement, so that the image of the mercury and liquid thread is magnified and thrown on a ground glass screen, before which the observer places himself. Or the indications may be photographed by throwing the image of the mercury thread thus formed on sensitive paper moving with a continuous motion in any of the methods employed in self-registering meteorological instruments.

Secondly. I will now proceed to describe in what manner I employ the motions of mercury in contact with an electrolytic liquid in a capillary tube for the purpose of acting as a relay to a local circuit

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containing a telegraphic instrument so as to produce the proper series of motions necessary to work it efficiently.

If the telegraphic instrument placed in the local circuit be constructed with an electro-magnet, so that its motions are produced by the alternate action of an electric current and a reacting spring, or if it be so constructed as to produce marks by means of the action of a current in one direction only on chemically prepared paper, the means I adopt to cause the motions of the mercury in the tube to open and close the circuit containing the telegraphic instrument are somewhat as follows :—

The mercurial relay is a glass tube, the internal diameter of which is about $^1/_{60}^{th}$ of an inch, more or less. It is bent upwards at its two ends, whilst the intermediate portion remains horizontal, and is placed on a frame which is held in position by a clamp. An insulated pillar has an arm, which carries at its end a platinum wire or steel needle, which by means of an adjusting screw may be brought nearly to the level of the mercury in the tube. The pillar and the arm have each an adjustment, so that the wire may be brought in the same line with the bore of the tube. Two platinum wires are inserted in the side of the tube touching the mercury within it. The outer ends of these platinum wires dip into two small cups containing mercury, or are clamped in binding screws. The tube is charged with mercury, excepting a small space between the platinum wires, which is filled with the electrolytic liquid; or several small spaces thus filled may be interposed in the mercury thread between the insertions of the wires as the sensibility of the motions appear hereby to be increased. If a platina wire be used for the plunger this liquid may be diluted sulphuric acid; but if a steel wire be employed, which is preferable on account of its having less adhesion to mercury than platina has, I recommend the employment of dilute carbolic acid. The adhesion of platina wire is reduced by coating it with black lead.

The connection of this relay with the local circuit containing the telegraphic instrument and with the line is as follows :—The local circuit consists of the receiving telegraphic instrument and a voltaic battery, consisting of one or more elements. One pole of this local circuit is connected with the plunger, and the other with the platina wire passing through the side of the tube into the mercury thread. One platina wire is connected with the telegraphic line, and the other with the earth line, or, if the station is an intermediate one, with the continuation of

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the telegraphic line, alternately inverted currents being sent through the line from the transmitting station. When the current is in one direction the mercury in one end of the tubes is raised, and that in the other end is depressed, and the mercury in the former touching the wire completes the circuit. When the current is in the opposite direction the mercury in the former falls and breaks the circuit, while it rises in the other. The durations of the currents and intervals in the local circuit depend on the respective intervals between the alternate currents in the transmitting instrument.

When a telegraphic instrument of the "Morse" construction is placed in the receiving local circuit a current inverter with two keys must be placed at the transmitting station.

When the printing receiver of my automatic telegraphic system described in the Specification of Letters Patent granted to me dated January 28th 1867, No. 220, is placed in the local circuit the adjustment of the armature of the electro-magnet must be so set as to allow it to act only on one side, so that the marking roller is removed from the paper by the reacting spring instead of by a reverse current. The transmitter of that system, described in the same Specification, must be placed at the transmitting station.

I mention these two telegraphic systems as they are those most generally adopted in this country, but it is easy to see what modifications are necessary to enable other instruments to work by means of this relay; but in all cases it is necessary that the transmitting instrument shall be actuated by alternately inverted currents.

A different arrangement of the mercurial relay is required when it is applied to telegraphic receiving instruments which are actuated by currents in alternate opposite directions and worked by electro-magnets. The sole difference in the construction of the relay is that a similar plunger, and with the same adjustments as that applied to one end of the tube, is applied also on the other end. The electro-magnet of the receiving instrument is surrounded by two independent coils. The ends of one of these coils are connected respectively with the plunger and one of the platina wires, and the ends of the other with the other plunger and the other platina wire. Two equal voltaic batteries are placed in the two circuits thus formed.

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Sir C. Wheatstone's Improvements in Telegraphic Signals.

The action consequent on this arrangement is as follows:—When the line current is positive the mercury in one end of the tube ascends and completes the circuit, and the armature is attracted in one direction; but when it is negative the mercury in the other end ascends and completes the circuit, which causes the armature to be attracted in the opposite direction. The same transmitters at the sending station are suitable for the relay with double local circuit as for the relay with a single local circuit previously described.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by Robert Sabine, of Cumberland Terrace, Regent's Park, in the County of Middlesex, one of the Executors of Sir Charles Wheatstone, Knight, who departed this life on the 19th day of October 1875, late of Park Crescent, Regent's Park, in the County of Middlesex, in the Great Seal Patent Office on the 28th January 1876.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, Robert Sabine, of Cumberland Terrace, Regent's Park, in the County of Middlesex, one of the Executors of Sir Charles Wheatstone, Knight, late of Park Crescent, Regent's Park, in the County of Middlesex, who departed this life on the Nineteenth day of October, One thousand eight hundred and seventy-five, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Fifth day of August, in the year of our Lord One thousand eight hundred and seventy-five, in the thirty-ninth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto him, the said Sir Charles Wheatstone, Her special license that he, the said Sir Charles Wheatstone, his executors, administrators, and assigns, or such others as he, the said Sir Charles Wheatstone, his executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improvements in the Mode of and Apparatus for Applying Electricity

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TO GIVE TELEGRAPHIC SIGNALS AND WORK TELEGRAPHIC RELAYS," upon the condition (amongst others) that he, the said Sir Charles Wheatstone, his executors or administrators, by an instrument in writing under his, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said Robert Sabine, as one of such executors of the said Sir Charles Wheatstone, deceased as aforesaid, do hereby declare the nature of the said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say :—

The present Invention, which is represented in the accompanying Drawings, consists in a method or methods of employing for telegraphic purposes the motions produced when mercury is in contact with an electrolytic liquid within a tube of narrow calibre, and electric currents are transmitted through them.

The first part of the Invention relates to the employment of these motions as telegraphic signs instead of the motions of magnetized needles within electric coils, or other means having the same object in view which are at present in use.

The second part of the Invention relates to the employment of these motions for the purpose of completing one or two local circuits, by which a telegraphic instrument either recording permanent or giving fugitive signs, or producing sounds, may be brought into action by means of electric currents transmitted through the main circuit.

The following is one manner in which the first part of the Invention may be carried into effect :—A capillary tube *b*, *c*, Figure 1, about $^1/_{60}{}^{th}$ of an inch internal diameter, and about 6 inches in length, turned upwards at its ends, and terminating at its vertical ends in two reservoirs or cups *a*, *d*, is fixed horizontally on a board A, B, C, D, having adjusting screws *e*, *f*, *g*, for the purpose of obtaining a proper level. This tube *b*, *c*, is filled with mercury, which rises into the cups *a*, *b*, and

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nearly fills them; but in the middle of the capillary tube a small quantity of dilute sulphuric acid or other conducting electrolytic liquid is introduced, occupying a space *h* of about a quarter of an inch more or less, and kept in the middle by proper levelling. Immediately above the cups *a*, *d*, and plunging into the mercury, are two platina wire *i*, *i*, insulated, except at their extremities, so that they may not come in contact with any electrolytic liquid at the surface. These wires *i*, *i*, are in metallic connection with binding screws *k*, *l*, which are connected, one with the telegraphic line wire and the other with the earth wire.

The transmitting instrument, Figure 2, placed at the other end of the telegraphic line, is a current inverter E, with two keys *m*, *n*, connected with a voltaic battery V, which, according as the one or the other key is touched, transmits a positive or a negative current to the line. The motion of the mercury thread in the receiving relay is always in the direction of the current, that is, from the copper to the zinc poles of the battery through the telegraphic line. The construction of a current inverter with two keys being well known, need not here be described.

When a key is kept depressed and the current consequently continues in the same direction the column of mercury moves continuously forward towards one of the reservoirs *a*, *d*. This motion may, by means of the reversing key at the transmitting station, be checked, intermitted, or reversed, so that all the signals which a single needle magnetic telegraph is capable of showing may be exhibited at the receiving station. The motions, whether they follow in the same or in opposite directions, are distinctly marked, and may be easily read. A single voltaic element of small dimensions will cause these motions through many hundred miles of standard telegraphic wire. If the power employed be too great the column of mercury will have a tendency to divide itself, but this, if not carried too far, will not injuriously affect the indications. The same construction of the transmitting key is equally applicable when the "Morse" alphabet is to be employed; the manipulation only will be different. The succession of long and short currents which in this alphabetic system constitutes the sign of a letter is effected by successively touching the same key, but a different key must be touched for each alternate letter. A great advantage is hereby obtained; the change of direction in the motions indicates clearly the transition from one letter to another, so that no

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error can arise from the running of the dots and dashes of one letter into those of the subsequent one.

Instead of the electrolytic thread dividing a mercury column as above described, the capillary tube *b*, *c*, and reservoirs *a*, *d*, may be filled with the electrolytic liquid, and the short space with mercury, or one half of the tube may be filled with mercury and the other half with the electrolytic liquid; in all these cases the motions at the points of junction of the two liquids may be equally well observed, but the method above described is preferable.

To render the indications of the mercury thread more visible the tube *b*, *c*, may be placed in a camera arrangement, so that the image of the mercury and liquid thread is magnified and thrown on a ground glass screen, before whichthe observer places himself. Or the indications may be photographed by throwing the image of the mercury thread thus formed on sensitive paper, moving with a continuous motion in any of the methods employed in self-registering meteorological instruments.

Secondly, I will now proceed to describe in what manner the motions of mercury in contact with an electrolytic liquid in a capillary tube are employed for the purpose of acting as a relay to a local circuit containing a telegraphic instrument, so as to produce the proper series of motions necessary to work it efficiently.

If the telegraphic instrument placed in the local circuit be constructed with an electro-magnet, so that its motions are produced by the alternate action of an electric current and a reacting spring, or if it be so constructed as to produce marks by means of the action of a current in one direction only on chemically prepared paper, the means adopted to cause the motions of the mercury in the tube to open and close the circuit containing the telegraphic instrument are somewhat as follows:—

The mercurial relay is represented at Figure 3. It consists of a glass tube *a*, *b*, *c*, *d*, the internal diameter of which is about $^1/_{60}{}^{th}$ of an inch, more or less; it is bent upwards at its two ends *a*, *d*, whilst the intermediate portion *b*, *c*, remains horizontal and is placed on a frame A, B, C, D; it is held in position by a clamp *e*. An insulated pillar *f* has an arm *g*, which carries at its end a platinum wire or steel needle *h*, which by means of an adjusting screw may be brought nearly to the level of the mercury in the tube. The pillar *f* and the arm *g* have each

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an adjustment, so that the wire may be brought in the same line with the bore of the tube. Two platinum wires *i*, *i*, are inserted in the side of the tube, touching the mercury within it; the outer ends of these platinum wires dip into two small cups *k*, *l*, containing mercury or are clamped in binding screws. The tube is charged with mercury excepting a small space between the platinum wires, which is filled with the electrolytic fluid. Or several small spaces thus filled may be interposed in the mercury thread between the insertions of the wires, as the sensibility of the motions appears hereby to be increased. If a platina wire be used for the plunger this liquid may be diluted sulphuric acid, but if a steel wire be employed, which is preferable, on account of its having less adhesion to mercury than platina has, it is recommend to employ dilute carbolic acid.

The connection of this relay with the local circuit containing the telegraphic instrument and with the line is as follows:—

The local circuit consists of the receiving telegraphic instrument E, and a voltaic battery V, consisting of one or more elements. One pole of this local circuit is connected with the plunger *h* by means of the binding screw *o*, and the other with the nearest platina wire passing through the side of the tube *a*, *b*, *c*, *d*, into the mercury thread. One platina wire is connected with the telegraphic line, and the other with the earth line by means of the binding screws, or if the station is an intermediate one with the continuation of the telegraphic line. Alternately inverted currents being sent through the line from the transmitting station, when the current is in one direction the mercury in one end of the tube is raised and that in the other end is depressed, and the mercury in the former touching the wire *h* completes the circuit. When the current is in the opposite direction the mercury in the former falls and breaks the circuit while it rises in the other. The durations of the currents and intervals in the local circuit depend on the respective intervals between the alternate currents in the transmitting instrument.

When a telegraphic instrument of the "Morse" construction is placed in the receiving local circuit a current inverter with two keys must be placed in the transmitting station.

When the printing receiver of the automatic telegraphic system described in the Specification of Letters Patent granted to the late Sir C. Wheat-

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stone, dated January 28th 1867, No. 220, is placed in the local circuit the adjustment of the armature of the electro-magnet must be so set as to allow it to act only on one side, so that the marking roller is removed from the paper by the reacting spring, instead of by a reversed current. The transmitter T of that system described in the same Specification must be placed at the transmitting station.

I mention these two telegraphic systems, as they are both well known in this country, but it is easy to see what modifications are necessary to enable other instruments to work by means of this relay, but in all cases it is necessary that the transmitting instrument shall be actuated by alternately inverted currents.

A different arrangement of the mercurial relay is required when it is applied to telegraphic receiving instruments which are actuated by currents in alternate opposite directions, and worked by electro-magnets. The sole difference in the construction of the relay represented at Figure 4 is that a similar plunger and with the same adjustments as that applied to one end of the tube is applied also on the other end. The electro-magnet E of the receiving instrument is surrounded by two independent coils; the ends of one of these coils are connected respectively with the plunger *h* and one of the platina wires *i*, *i*, and the ends of the other with the other plunger *h* and the other platina wire *i*. Two equal voltaic batteries V, V, are placed in the two circuits thus formed.

The action consequent on this arrangement is as follows:—When the line current is positive the mercury in one end of the tube ascends and completes the circuit, and the armature is attracted in one direction, but when it is negative the mercury in the other end ascends and completes the circuit, which causes the armature to be attracted in the opposite direction. The same transmitters at the sending station are suitable for the relay with double local circuit as for the relay with a single local circuit previously described.

Having now described the said Invention of a new method of giving telegraphic signs and constructing telegraphic relays, I would here remark that although in the course of the aforesaid description I have necessarily mentioned many contrivances already known and in use, such as the telegraphic receiving instruments placed in the local circuit, and the telegraphic transmitting instruments placed in the main line, I wish it to be understood that I make no claim for them, but only for the

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means by which they are connected with this system; but what I claim as the said Invention is as follows:—

First. Employing for telegraphic signals the motions produced when mercury is in contact with an electrolytic liquid within a tube of narrow calibre and electric currents are transmitted through them, and the means substantially as herein shown and described for carrying the same into effect.

Secondly. Employing the aforesaid motions for the purpose of completing one or more local circuits by which a telegraphic instrument may be brought into action by means of electric currents transmitted through the main circuit, and the means substantially as herein shown and described for carrying the same into effect.

In witness whereof, I, the said Robert Sabine, have hereunto set my hand and seal, this Fourteenth day of December, in the year of our Lord One thousand eight hundred and seventy-five.

ROBERT SABINE. (L.S.)

LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1876.

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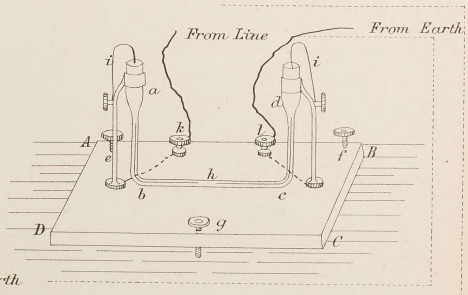
A.D. 1875. Aug. 5. N° 2771.
WHEATSTONE'S Specification.

(1 SHEET)

FIG. 1.



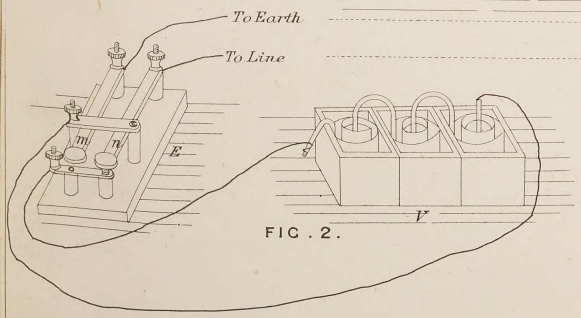


FIG. 2.

FIG. 3.

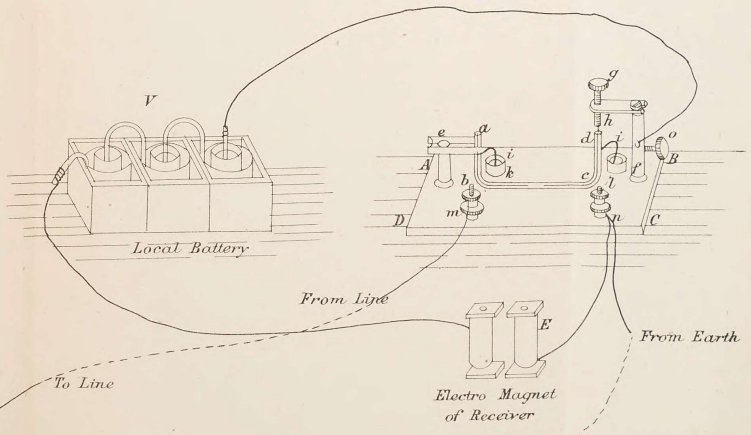


FIG. 3a.

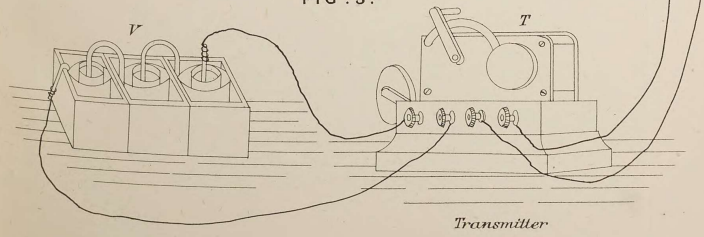
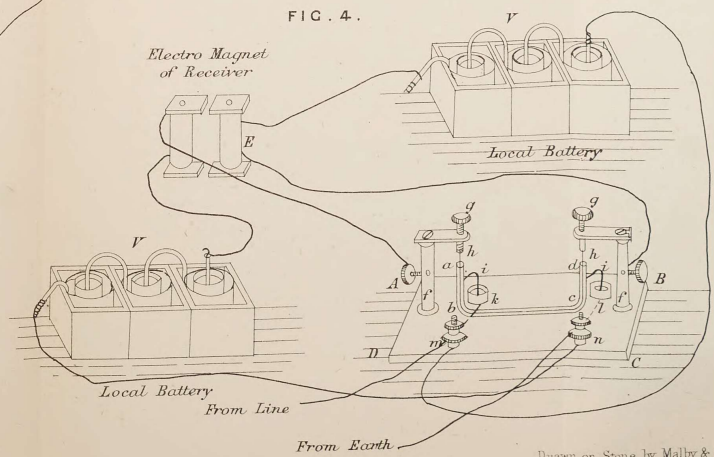


FIG. 4.



The filed drawing is not colored.

Drawn on Stone by Malby & Sons.

London Printed by George Edward Eyre and William Spottiswoode
Printers to the Queen's most Excellent Majesty 1876

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